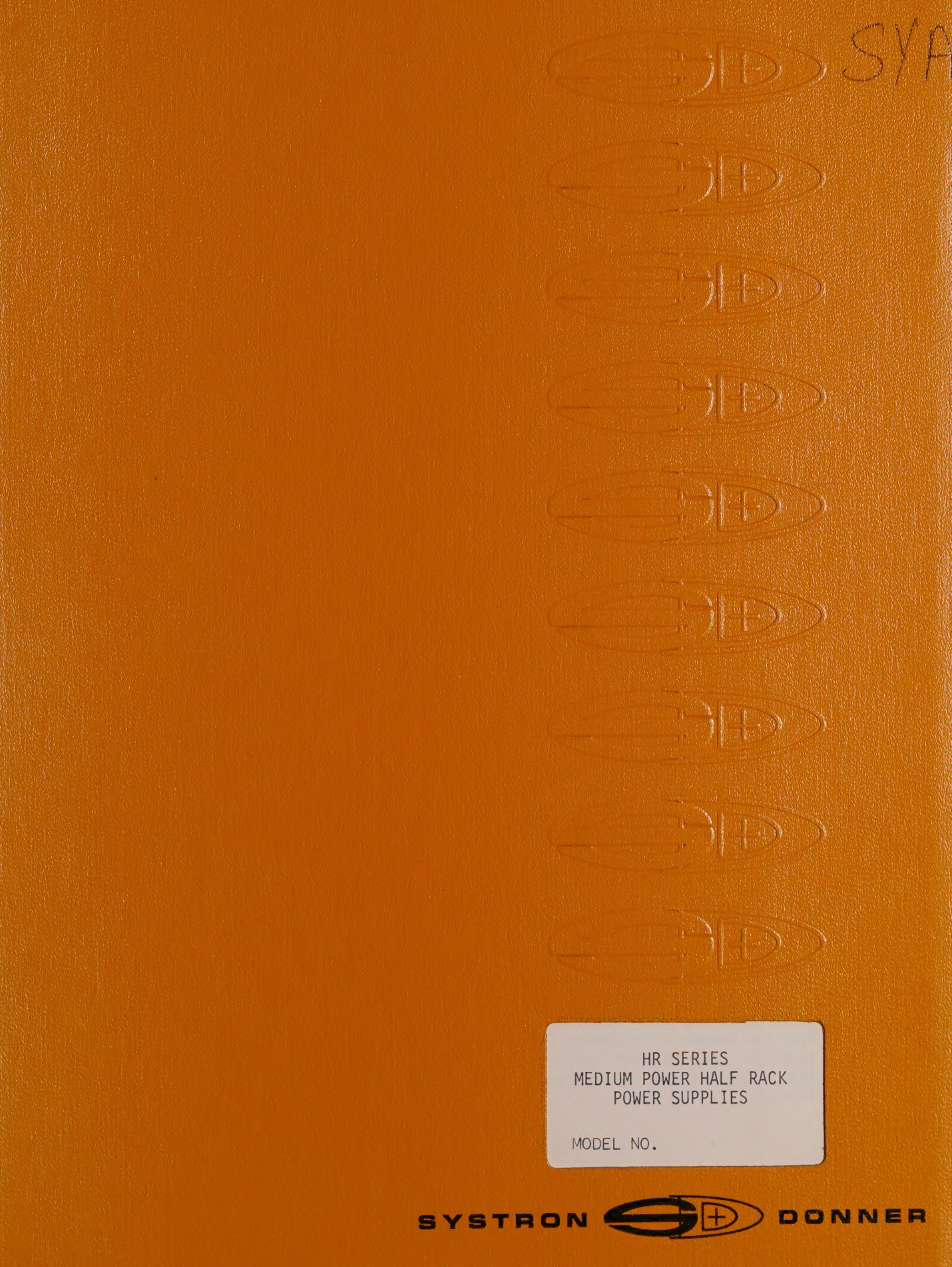


HR SERIES
MEDIUM POWER HALF RACK
POWER SUPPLIES

MODEL NO.

SYSTRON DONNER

INSTRUCTION MANUAL

This manual describes the HR Series Half Rack Power Supplies. It contains information on the following:

Model HR20-12C OV
Model HR40-10C OV
Model HR60-8C OV
Model HR160-3C OV

HR SERIES
MEDIUM POWER HALF RACK
POWER SUPPLIES

MODEL NO.

Copyright © 1975 Systron-Donner Corporation

SYSTRON DONNER CORPORATION

CONCORD INSTRUMENT DIVISION
10 Systron Drive • Concord, California 94518 • U.S.A.
Tel: (415) 676-5000 • TWX: 910-481-9479 • Cable: SYSTRONDONNER

FSCM No. 52542

Printed in U.S.A.

SYSTRON DONNER
CORPORATION

WARRANTY

Every Systron-Donner power supply carries a five year warranty. The company warrants each standard power supply of its manufacture to be free from defects in material and workmanship. Our obligation under this warranty is limited to making good at our factory any part or parts including semiconductors, which shall, within five years after delivery to the original purchases, be returned to us with transportation charges prepaid; and to labor incident to servicing or adjusting any instrument returned to our factory, within a period of two years after delivery to the original purchaser; provided that our examination shall disclose to our satisfaction a basic defect in material or workmanship. Warranty returns must be authorized in advance, by the factory. We reserve the right to made changes in the design of our equipment without incurring any obligation with respect to equipment previously produced. This warranty is in lieu of all other obligations or liabilities expressed or implied, and specifically excludes all liability for consequential damages and costs.

RECEIVING INSPECTION

Every Systron-Donner instrument is carefully inspected and is in perfect working order at the time of shipment. Each instrument should be checked as soon as received. If the unit is damaged in any way, or fails to operate, a claim should immediately be filed with the transportation company.

REPAIRS

Whenever a Systron-Donner instrument requires service, the nearest Systron-Donner representative should be contacted; all representatives will provide immediate service or arrange factory returns when necessary.

Please specify both model and serial number in all correcpondence concerning Systron-Donner instruments. Address all inquiries on operation or applications to your nearest service representative; or, Service Manager, Service Division, Systron-Donner Corporation, 935 Detroit Avenue, Concord, California 94518.

SYSTRON DONNER
Instrument Division
10 Systron Drive • Concord, California 94518 • Phone (415) 825-9810 • TWX 910-481-9479

Thank You. We appreciate your confidence in our products. Systron-Donner wishes to ensure your on-going satisfaction with this instrument by maintaining it at its specified performance throughout its warranty period. If assistance is required, please feel free to contact one of our Factory, Regional or Local Service Centers listed on the reverse side of this card.

If service, calibration or parts are required beyond the warranty period, please contact the Service Center nearest you. They will insure your continuing satisfaction with our equipment.

To insure complete warranty coverage of this instrument and to help us serve you better, please complete the warranty registration card below and return it immediately.

Sincerely,

Neil Harrer

Neil A. Harrer
Product Manager, Customer Service

The Post Office will not deliver mail without proper postage

Systron-Donner Corporation
Instrument Division
10 Systron Drive
Concord, CA 94518

S-D Service Centers

Factory Service

INSTRUMENT DIVISION
10 Systron Drive
Concord, CA 94518
Phone: (415) 825-9810
TWX: 910-481-9479

REGIONAL SERVICE CENTERS

EAST
115 Grand Avenue
Englewood, NJ 07631
Phone: (201) 871-3916
(201) 871-3917

LOCAL SERVICE CENTERS

WASHINGTON, D.C.
7643 Fullerton Road
Springfield, VA 22153
Phone: (703) 451-6500

SOUTHWEST
312 N. Central Expressway
Suite 212
Richardson, TX 75080
Phone: (214) 231-5693

Warranty Registration Card

MODEL NO. _____ SERIAL NO. _____ DATE RCV'D _____

Company _____ Department _____

Name _____ Title _____

Address _____ Phone (_____) _____

City _____ State _____ Zip _____

PRE-SALE ASSISTANCE	DELIVERY	INSTRUMENT PERFORMANCE	INSTRUMENT QUALITY
☐ Excellent	☐ Early	☐ As Expected	☐ Excellent
☐ Fair	☐ On Time	☐ Good	☐ Fair
☐ Poor	☐ Late	☐ Defective	☐ Poor

SERVICE CONTRACT AFTER WARRANTY? ☐ Yes ☐ No ☐ Check Later

PROVISIONING PARTS REQUIRED? ☐ Yes ☐ No ☐ Check Later

THIS EQUIPMENT WAS TO: ☐ Replace existing instrument ☐ Expand equipment capability

WHAT INFLUENCED YOUR DECISION TO BUY? ☐ Advertising ☐ Salesman ☐ Other

COMMENTS: _____

TABLE OF CONTENTS

SECTION			PAGE
1	DESCRIPTION		
	1.1	Introduction	1-1
	1.2	Description	1-1
	1.3	General Features	1-1
	1.3.1	Constant Voltage Mode	1-1
	1.3.2	Constant Current Mode	1-1
	1.3.3	Automatic Current Limiting	1-2
	1.3.4	Automatic Overvoltage Protection	1-2
	1.3.5	Remote Programming - Voltage Output	1-2
	1.3.6	Remote Programming - Current Limiting	1-2
	1.4	Precautionary Measures	1-2
	1.4.1	Wire Size	1-2
	1.4.2	Voltage Regulator and Inverter Inputs	1-2
	1.4.3	System Considerations	1-2
	1.4.4	Terminal Post Resistance	1-3
	1.5	Specifications	1-3
2	INSTALLATION AND OPERATION		
	2.1	Mechanical Installation	2-1
	2.2	Electrical Connections	2-1
	2.3	Controls	2-4
	2.4	Operation	2-5
3	THEORY OF OPERATION		
	3.1	General	3-1
	3.2	Optional Features	3-2
4	MAINTENANCE		
	4.1	General	4-1
	4.2	Loads and Interconnections	4-1
	4.3	Troubleshooting	4-1
5	CALIBRATION		
	5.1	General	5-1
	5.2	Test Equipment Required	5-1
	5.3	Calibration Procedure	5-1

LIST OF TABLES

Table			
	1-1	Specifications	1-3
	2-1	AC Input Wire Size	2-2
	2-2	Shorting Link Application, Rear Panel	2-3
	2-3	Shorting Link Application, Front Panel	2-4
	2-4	Front Panel Controls	2-4

SECTION PAGE

LIST OF ILLUSTRATIONS

Figure	2-1A	Set Up for Parallel Operation	2-6
	2-1B	Set Up for Parallel Operation	2-6
	2-2	Parallel Operation Connections	2-6
	3-1	Block Diagram	3-3
	5-1	Constant Voltage Operation	5-5
	5-2	Constant Current Operation	5-5

APPENDICES

List of Electrical Parts
Schematic Diagrams

SECTION 1
DESCRIPTION

1.1 INTRODUCTION

The Medium Power Half Rack (HR) Series power supplies are flexible and dependable sources of DC power, which can be used to meet a variety of needs. These needs may range in scope from inspection and production testing, to laboratory bench testing and systems applications.

The wide range of outputs available makes these units well suited for use as basic laboratory power sources. The ability to provide power packaged in minimum space with high reliability meets the demads of most systems requirements.

This instruction manual provides general characteristics and specifications, operating procedures, theory of operation, maintenance and troubleshooting, calibration, parts lists and related schematics for Models HR20-12COV, HR40-10COV, HR60-8COV and HR160-3COV.

1.2 DESCRIPTION

The Half Rack Series units are designed for laboratory, bench, test, inspection, production and systems applications. Their unique design provides operating flexibility and high reliability at high power output levels.

1.3 GENERAL FEATURES

Automatic short circuit protection, remote voltage programming, remote sensing, front or rear, no turn on/turn off transients and overvoltage protection are all standard features in the Half Rack Series. Output, Sensing and Remote Programming terminals are located on a terminal board mounted on the rear panel of the unit. The AC power switch, AC pilot lamp, current mode indicator lamp, current and voltage controls and appropriate metering devices are all located on the front panel. For convenience, additional output and sensing terminals have been provided on the front panel.

1.3.1 Constant Voltage Mode

A constant voltage is maintained across the output terminals at any preset value from zero to rated voltage output, provided that the load does not draw more than either the rated output current or more than the preset limiting current value determined by the front panel current control settings.

1.3.2 Constant Current Mode

Constant current operation is achieved by maintaining a constant voltage across an internal current sensing resistor. An automatic crossover network changes the mode of operation from Constant Voltage to Constant Current when the current demand reaches that of the preset current adjust control. The point at which the operating mode automatically changes is a function of variations in load conditions. The crossover point is adjustable, and can be established anywhere within the current and voltage range of the unit.

1.3.3 Automatic Current Limiting

Short circuit protection is provided by the Automatic Current Limiting circuit which limits the maximum output current under all load conditions. The point at which automatic current limiting occurs is variable, and may be selected anywhere between 1% of the rated current output and maximum rated current output of the unit. In the event of a short circuit, the output voltage will drop to zero, and will return to its previous level only upon removal of the short circuit.

1.3.4 Automatic Overvoltage Protection

Automatic Overvoltage (OV) protection prevents the output voltage from exceeding approximately 10% or 1.5 volts above the programmed voltage. An internal sensitivity control is provided to desensitize the overvoltage protection circuit.

1.3.5 Remote Programming - Voltage Output (RVP)

Remote Programming is provided in the voltage mode of operation, and may be utilized over the entire voltage range of the unit. The scale factor for Remote Voltage Programming is 100 ohms per volt.

1.3.6 Remote Programming - Current Limiting (RIP)

Remote Programming is provided to set the current limiting point. The scale factor for Remote Current Programming is the inverse of 250 ohms. 0 ohm provides maximum rated current, 250 ohms provides minimum current.

1.4 PRECAUTIONARY MEASURES

1.4.1 Wire Size

To assure proper regulation under all load conditions, and to prevent severe distortions of the AC line voltage, it is very important to take into consideration the physical size and current handling capabilities of the input power line. Serious losses in regulation and an increase in ripple may result from underrated or overloaded AC input lines. The maximum AC impedance from the breaker box to the power supply input should not exceed 0.75 ohms.

1.4.2 Voltage Regulator and Inverter Inputs

Do not use voltage regulators or inverters as a primary power source. The outputs of these devices are usually not sinusoidal in nature, and if used as the AC source for the power supply, will cause serious loss of regulation of the power supply output. Capacitive input filtering used for semiconductor power supplies requires charging to the peak of the rectified AC wave which nonsinusoidal AC sources may not provide.

1.4.3 System Considerations

In systems applications it is recommended that each power supply input power line be run separately to the AC distribution box, in order to minimize cross coupling and interaction between equipment. Do not run sensitive signal leads

such as the remote sensing leads in the same cable as the AC input without shielding. To keep the AC ripple in the output to a minimum, it is recommended that the AC input cables should not be run in close proximity to the output load cables.

1.4.4 Terminal Post Resistance

All terminals and shorting links serving Outputs, Sensing and Programming must be securely tightened before use. Serious loss of regulation and an increase in ripple can result due to a voltage drop caused by loose terminals and shorting links.

The specifications cited herein for regulation and ripple can be readily attained on every power supply providing the proper method of measurement is employed. The major consideration is that the highly stable meter and oscilloscope, specified in the calibration procedures, must be connected to the sensing terminals and not the load terminals. The reason for this precaution is that the voltage drop between the load terminals and sensing terminals will yeild an inaccurate regulation ripple measurement.

1.5 SPECIFICATIONS

Table 1-1 is complete list of standard specifications for the Medium Power Half Rack Series.

TABLE 1-1 SPECIFICATIONS

ELECTRICAL SPECIFICATIONS

Constant Voltage Mode With Adjustable Current Limiting

Input: 105-125 VAC, 55-65 Hz (200-240 VAC, 50 or 400 Hz available).

Output: Floating; isolated from ground, 300 VDC maximum.

Model	Volts	Max. Amps at Ambient of: 40°C	60°C	71°C	Nominal* AC Line Current RMS Amps
HR20-12C OV	0 to 20	12	10	7.5	6
HR40-10C OV	0 to 40	10	7.5	4	8
HR60-8C OV	0 to 60	8	5.7	4.4	7
HR160-3C OV	0 to 160	3	2.5	2	2

*At nominal 115 VAC line, 40°C, maximum voltage and current output.

Regulation, Line: 0.01% or 2 mV[1], for 105-125 VAC line change, at any output within specifications.

Regulation, Load: 0.01% or 3 mV[1], no load to full load at any output within specifications.

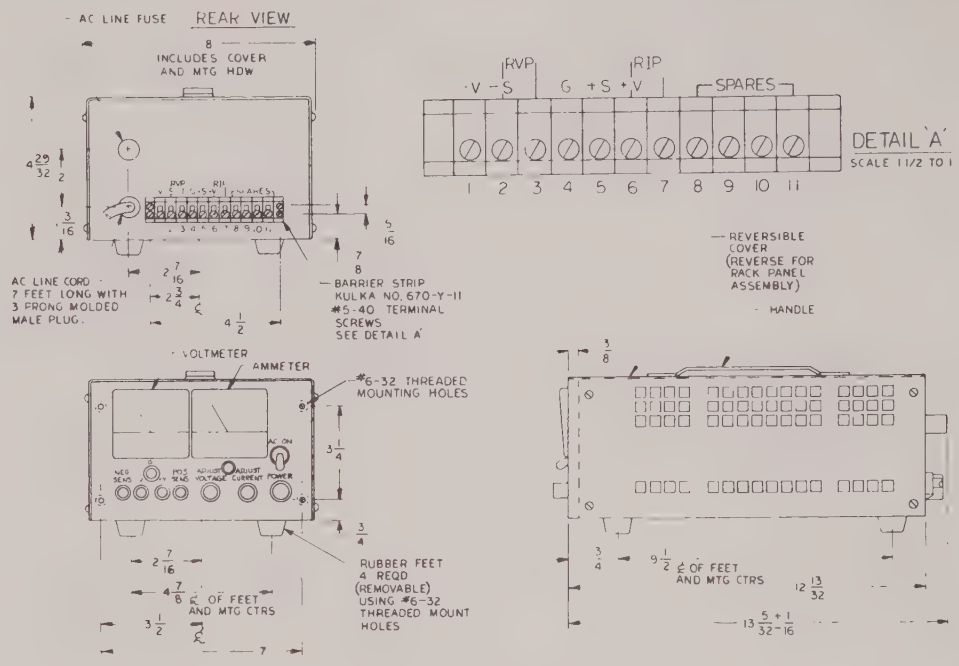
TABLE 1-1 SPECIFICATIONS (Cont'd)

ELECTRICAL SPECIFICATIONS (Cont'd)	
Ripple:	Less than 0.5 mV RMS, 15 mV p-p.
Stability:	0.05% or 18 mV[1] for 8 hours after warm-up. Measured at constant line voltage, load and ambient temperature.
Temperature Coefficient:	(0.02% +400 μV)/°C.
High Stability (Option X):	0.01% or 2 mV[1] with a T.C. of (0.01% (0.01% +100 μV)/°C.
Temperature Range:	-20°C to +71°C.
Recovery Time:	Less than 50 microseconds to recover within 0.05% or 15 mV[1] of output voltage for 25% step change in rated load.
Output Impedance:	DC-1 kHz; 10 million ohms nominal.
Short Circuit Protection:	Automatic Adjustable Current Limiting (ACL) variable from 1% to 100% of rated current.
AC Power Input Protection:	Fuse.
Remote Programming:	All units remotely programmable over output voltage range. Scale factor approximately 100 ohms/volt.
Remote Sensing:	Maintains rated regulation directly at the load. Maximum line drop 0.5 V per leg.
Voltage Adjustment Range:	Continuously adjustable concentric vernier controls.
Overvoltage Protection:	Automatic fast acting overvoltage protection tracks the preset output voltage.
Constant Current Mode With Adjustable Voltage Limiting	
Current Range:	1% to rated current output.
Voltage Compliance:	0 to rated output voltage.
Regulation, Line:	0.5% I_{rated} for 105-125 VAC line change at any output within specifications.
Regulation, Load:	0.5% I_{rated} output current change for the maximum change in load resistance within the rated voltage compliance range.
Ripple:	0.25% or 5 mA[1].
Stability:	0.5% I_{rated} for 8 hours after warm-up. Measured at constant line voltage, load and ambient temperature.

TABLE 1-1 SPECIFICATIONS (Cont'd)

Constant Current Mode With Adjustable Voltage Limiting (Cont'd)	
Temperature Coefficient:	0.1% I_{rated}/°C.
Remote Programming:	$Rpgm = 250 \left(1 - \frac{1\ Load}{1\ Rated}\right)$
GENERAL AND PHYSICAL SPECIFICATIONS	
Design Principle:	Phase controlled pre-regulation with precision series pass regulation.
Operational Modes:	Constant Voltage with adjustable current limiting; Constant Current with adjustable voltage limiting; Automatic Crossover.
Mode Indicator:	Front panel mode indicator light indicates when supply is operating in the constant current or current limiting mode.
Controls:	
Voltage:	Coarse and Fine; 0 to rated output; front panel.
Current:	Coarse and Fine; 1% I_{rated} to rated output; front panel.
Input Power:	Front panel switch and indicator.
Metering:	
Voltage:	Front panel voltmeter.
Current:	Front panel ammeter.
Terminals:	
Front Panel:	Positive Output (+V); Negative Output (-V); Positive Sensing (+S); Negative Sensing (-S); Ground (G).
Rear Panel:	(1) Negative Output -V; (2) Negative Sensing (-S); (2-3) Remote Voltage Programming RVP; (4) Ground G; (5) Positive Sensing +S; (6) Positive Output +V; (6-7) Remote Current Programming RIP; (8-11) Spares.
Rack Mounting:	RPA-1 (Single), RPA-2 (Dual) rack adapters, mounts two unitd side by side; 5-1/4" rack height.
Size:	7-3/4"W x 4-7/8"H x 14"D.
Weight:	28 lbs.

[1]Whichever is greater.


AC LINE FUSE
REAR VIEW
INCLUDES COVER AND MTG HDW
AC LINE CORD 7 FEET LONG WITH 3 PRONG MOLDED MALE PLUG.
BARRIER STRIP KULKA NO. 670-Y-11 #5-40 TERMINAL SCREWS SEE DETAIL A
RVP
RIP
-V -S G +S +V
SPARES
1 2 3 4 5 6 7 8 9 10 11
DETAIL 'A'
SCALE 1 1/2 TO 1
REVERSIBLE COVER (REVERSE FOR RACK PANEL ASSEMBLY)
HANDLE
VOLTMETER
AMMETER
#6-32 THREADED MOUNTING HOLES
RUBBER FEET 4 REQD (REMOVABLE) USING #6-32 THREADED MOUNT HOLES
℄ OF FEET AND MTG CTRS
℄ OF FEET AND MTG CTRS

HR(C) Series

SECTION 2

INSTALLATION AND OPERATION

2.1 MECHANICAL INSTALLATION

General

If the Medium Power Half Rack Series power supplies are used in a portable bench type configuration, no special mechanical installation is required. However, if the units are rack mounted, special rack mounting adapters must be used to secure the units to the relay racks. Single (RPA-1) and dual (RPA-2) rack panel adapters are available.

Rack Panel Adapter Mounting

A) Remove the 6-32 screws which fasten the cover to the power supply chassis.
B) Remove and rotate the cover so that the front is now facing to the rear.
C) Fasten the cover securely in position with the 6-32 screws previously removed.
D) Attach the handles to the Rack Panel Adapter.
E) Stand the Rack Panel Adapter in front of the power supply. In order to mount the power supply properly, the top of the Rack Panel Adapter must face up. The top is distinguishabe from the bottom in that all the holes, including those for the handles, are in a straight row across the front of the Rack Panel Adapter.
F) Place the Rack Panel Adapter against the front panel, so that the four holes in the adapter line up with the four holes in the front panel. Fasten the adapter to the front panel with four 6-32 x 1/2 screws.

2.2 ELECTRICAL CONNECTIONS

Input, Power

A heavy duty 3 wire line cord and molded plug with grounding prong provides a path for input power to the unit.

The power handling ability of the AC power lines feeding AC power to the line cord must be considered, as serious losses in regulation and substantial increases in ripple can occur as a result of insufficient power handling capacity of these lines. The AC impedance from the breaker box to the power supply input connector should not exceed 0.75 ohms. All AC power line connections must be securely tightened, and any movable electric contact surface (such as the wiper arm of a variable transformer) should be kept clear of impedance producing oxide coatings.

Care should be exercised in selecting the proper wire size for the AC input lines. The figures listed in Table 2-1 will serve as a guide in making this selection.

TABLE 2-1 - AC INPUT WIRE SIZE

LENGTH OF RUN(SINGLE LEAD)	WIRE SIZE (AWG STANDARDS)
10 feet or less	16
10 feet to 20 feet	12
20 feet to 50 feet	10

Output, Rear Panel

An eleven terminal barrier strip mounted on the rear panel provides output, sensing, programming and ground connections. Table 2-2 SHORTING LINK APPLICATION, REAR PANEL, lists the various shorting link connections required for any of the various modes of operation.

Output, Front Panel

Five binding post terminals mounted on the front panel provide output, sensing and ground connections. Table 2-3 SHORTING LINK APPLICATION, FRONT PANEL, lists the various shorting link connections required for these modes of operation.

Front or Rear Panel Output Selection

Local or remote sensing and regulation is available from either the front or rear panel terminals. However, to maintain regulation, only one set of terminals may be used at a time. If the load is connected across the front panel output terminals, sensing (local or remote) connections must also be made from the front panel. If front panel output connections and rear panel sensing connections are made simultaneously to the load, regulation may deteriorate severely.

Shorting Link Application, Rear Panel

The power supply is shipped from the factory with shorting links in place across terminals 1 and 2, 2 and 3, 5 and 6, 6 and 7, of the rear panel barrier strip. In this configuration, and with the load connected across the rear panel output terminals, local sensing and programming operation from the rear panel is provided.

Additional operating configurations may easily be achieved by changing shorting link connections or adding external wiring and controls, as outlined in TABLE 2-2 - SHORTING LINK APPLICATION, REAR PANEL. However, the output of the power supply will become unregulated, unless the connections listed for at least one of the operating functions is made.

TABLE 2-2 SHORTING LINK APPLICATION, REAR PANEL

SELECTION	FUNCTION	CONNECTIONS REQUIRED
1	Local Sensing Local Programming	1 and 2; 5 and 6 2 and 3; 6 and 7
2	Local Sensing Remote Programming	1 and 2; 5 and 6 PGM resistors across 2 and 3 and/or 6 and 7
3	Remote Sensing Local Programming	1 and 2 connected at load (-) 5 and 6 connected at load (+) 2 and 3 and/or 6 and 7
4	Remote Sensing Remote Programming	1 and 2 connected at load (-) 5 and 6 connected at load (+) PGM resistors across 2 and 3; 6 and 7

NOTE: If the front panel terminals are to be used and local sensing is desired, place shorting links across the front panel -s, -v and +s, +v binding posts so that the regulation is maintained at the front panel terminals.

Shorting Link Application, Front Panel

Shorting links for the front panel binding post terminals are shipped with the unit, but are not installed. Upon installation of these shorting links, front panel local or remote sensing operation may be selected. However, it must be remembered that if sensing connections to the load are made from the front panel, output connections must also be made from the front panel. Front panel shorting link connections are shown below:

TABLE 2-3 SHORTING LINK APPLICATION, FRONT PANEL

Terminals	Condition	Function
-S and -V +S and +V	Connected Connected	Local sensing and regulation at front panel output terminals.
-S and -V +S and +V	Not Connected Not Connected	Remote sensing and regulation at load, using four separate and individual leads to load.

2.3 CONTROLS

Front Panel

TABLE 2-4 FRONT PANEL CONTROLS

Name	Function
AC Power	Toggle switch, controls input power.
Voltage Adjust (Coarse)	Potentiometer, adjusts voltage output.
Voltage Adjust (Vernier)	Potentiometer, adjusts voltage output.
Current Adjust (Coarse)	Potentiometer, adjusts current.
Current Adjust (Vernier)	Potentiometer, adjusts current.

Internal

All internal control settings have been factory preset, and require no additional adjusting. However, if it should become necessary to adjust any of the internal controls due to circuit changes caused by component aging or replacement, refer to the calibration section of this instruction manual.

2.4 OPERATION

Control Settings

Set all front panel controls fully CW so that unit will operate in the Voltage rather than Current Limiting mode.

Shorting Links

If Local Sensing rather than Remote Sensing operation is desired, ascertain that shorting links are in place across the appropriate terminals.

Grounding

Either side of the Output may be grounded, or the Output may be used in a floating condition.

Power On

Connect the power supply to a nominal AC power source. Set power switch S1 to AC-ON, and observe that pilot lamp DS1 glows.

Warm-Up

No warm-up time is necessary to place the unit into operation. However, a 30 minute warm-up period is recommended to reach rated stability.

Series Operation

To operate two or more power supplies in a series configuration, connect the output of each power supply in series. When operating in this mode, it is necessary to adjust the output of each unit independently. The output voltage is equal to the sum of the voltage settings of each power supply.

Parallel Operation

A) With rated resistive load connected across the output of power supply A as shown in Figure 2-1A, set VOLTAGE ADJUST control to desired output voltage and set CURRENT ADJUST control for maximum rated output current.

B) Connect power supply B as shown in Figure 2-1B. With no load across the output, set VOLTAGE ADJUST control for an output voltage 2 volts higher than the output voltage of power supply A. Place a short across the output terminals, and set the CURRENT ADJUST control for 1/2 the total load current requirement.

C) Remove all former output loads and connect the outputs of power supplies A and B in parallel with each other, and in parallel with the load, as shown in Figure 2-2.

D) If parallel operation of these two power supplies is desired for a systems application, it is important that both units be turned on simultaneously. It is therefore recommended that both power supplies be connected to a single large circuit breaker. Maximum output current will be twice that of either of the two power supplies, while minimum output current will be that of power supply B, or half the total load current.

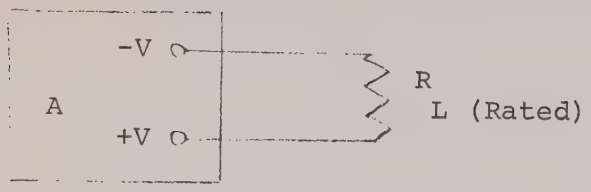


FIGURE 2-1A

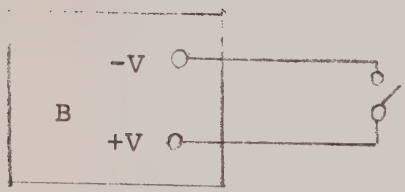


FIGURE 2-1B

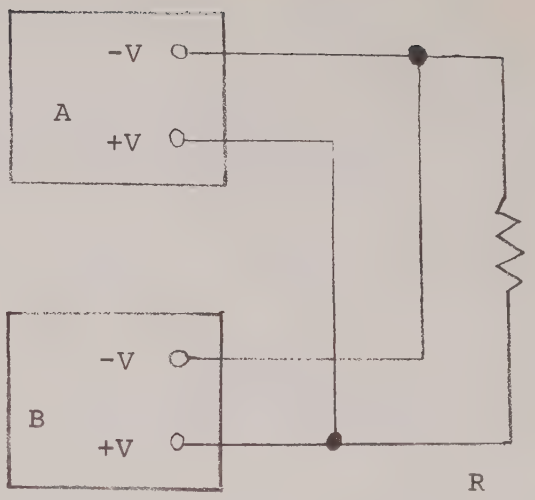


FIGURE 2-2

NOTE: If parallel operation of Trygon power supplies utilizing overvoltage (OV) protection is desired, the above procedure plus the following additional step must be performed:

1. Disconnect the gate lead from the OV SCR in power supply which is set to lower output voltage.

SECTION 3

THEORY OF OPERATION

3.1 GENERAL

The purpose of the Medium Power Half Rack Series power supplies is to transform and rectify the AC input into a well-regulated, stable and adjustable DC output. The following paragraphs describe the major circuits used in the power supplies. As each circuit is described, reference should be made to both the Block Diagram, Figure 3-1 and the Schematic Diagram in the rear of this manual.

Primary Input

Input power is obtained through power transformer T1, full wave rectifier diode sets CR1 and CR2, CR3 and CR6, CR4 and CR5, CR7 and CR8, and CR26 CR27, and filter capacitor C1, C16 and C17. Each rectifier set provides the necessary DC voltages to the various sections of the unit.

When AC power switch S1 is set to AC-ON, AC pilot lamp DS1 glows, and AC power is applied to the power transformer. Regulated DC output power is immediately available from the power supply.

Reference Supply

The rectified and filtered voltage from rectifiers CR1 and CR2 and filter capacitor C1 is pre-regulated by Coarse Reference Regulator zener CR12. This provides a stabilized DC voltage to Constant Current Source Q2, whose output is regulated by Precision Voltage Reference zener CR14. Constant Current Source Q1 controls the drive to Q2 and in turn is control led by Q2. The voltages developed across Constant Current Source References CR13 and CR14 are highly stable reference voltages established at a higher positive potential than the positive output of the supply.

Pre-Regulator

The purpose of the Pre-Regulator section is to maintain the unregulated input voltage on Input Filter Capacitor C16 at a suitable value compared to the output voltage in order to lower the power dissipation across the Series Pass section of the Series Regulator.

The method used to accomplish this is to "fire" a pair of SCR's (silicon controlled rectifiers), CR7 and CR8, at controlled points along the input sine wave to increase or decrease the potential to which the input filter capacitor may charge. The SCR's are "fired" (allowed to pass current) by the application of a positive pulse at the junction of gating resistors R55 and R56, from unijunction transistor Q11.(CR48 and CR49 are used to complete the full wave bridge on HR160-3C).

The unijunction transistor triggers the SCR's when charged sufficiently by timing capacitor C3 to cause conduction. The timing of the triggering pulse to the SCR's is a function of the voltage across Series Pass transistors and the AC voltage referenced by diode rectifiers CR3 and CR6, and Series Pass Voltage Adjust control R49.

The SCR's are turned off with each alternate half cycle of the input sine wave. Adjustment of R49 is factory set to the optimum full load diring point of the SCR's.

Series Regulator

The pre-regulated DC voltage from the SCR's is directed through the Series Pass transistors. The conduction of these transistors is controlled by circuitry which causes them to act as variable resistors. Their overall resistance varies in accordance with the need of the power supply to increase or decrease its output voltage or current.

The Series Pass transistors are controlled by several driver stages which amplify signals from the error amplifier.

Comparator and Error Amplifier

The voltage sensing and comparison is accomplished by differential amplifier Q10. A sample of the output voltage on the base of Q10 is compared to the stable reference voltage on the base of comparator Q9. An unbalance caused by a change in voltage at either the negative sensing terminal or across voltage adjustment controls R25 and R26 will appear as a voltage change in the collector of Q10.

This difference voltage is amplified by error amplifier Q6, and is used to regulate the Series Pass transistors via the Series Pass drivers. Error amplifier Q6 has two diode inputs to its base which form an OR gate for error signals. CR17 supplies error signals from the comparator, and CR16 supplies an error signal in the event of a short circuit, or if the power supply is driven into the current limiting mode of operation.

When operating in the current limiting mode, differential amplifier Q3 and Q4 become balanced, causing diode CR16 to conduct, and in turn, drives error amplifier Q6 toward cut-off. This signal also causes Q7 to conduct, thereby causing current mode indicator lamp DS2 to glow.

3.2 OPTIONAL FEATURES

Overvoltage (OV) Protection

If the output voltage should rise above the programmed output level, a portion of the signal developed across the OV sensitivity control will cause the OV sensor to conduct, which in turn, drives the OV Reference into conduction. The output of the OV SCR Driver is applied to the gate lead of the OV SCR, causing it to "fire". "Firing" of the OV SCR cuts off the Series Pass drivers and in turn, the Series Pass circuit.

If the overvoltage condition is caused by a short in the Series Pass circuit, the OV SCR will "fire", causing the OV fuse to open.

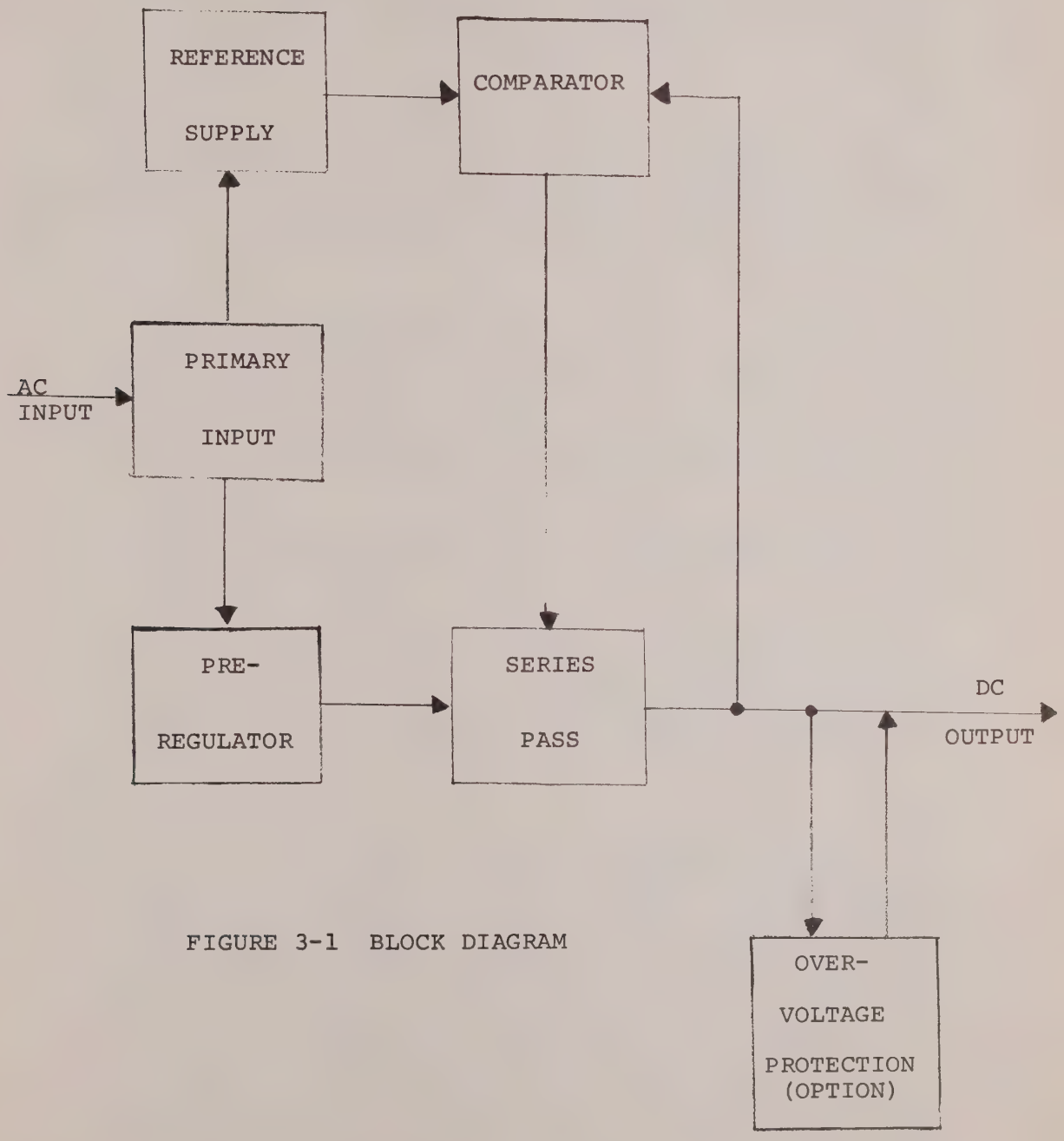


FIGURE 3-1 BLOCK DIAGRAM

SECTION 4
MAINTENANCE

- W A R N I N G -

High Voltages Are Present

Use Caution

4.1 GENERAL

This power supply is a precision instrument. It is strongly recommended that only experienced troubleshooting personnel perform troubleshooting operations or attempt to repair the unit. If the power supply appears to be malfunctioning at all, the following procedure is recommended for isolating possible defects.

4.2 LOADS AND INTERCONNECTIONS

1. Disconnect all interconnections and loads to which the unit is normally connected.
2. Place shorting links between rear panel terminals 1 and 2, 2 and 3, 5 and 6, 6 and 7. These connections must be securely amde, or deterioration of output regulation will occur.
3. Connect a resistive dummy load across output terminals 1 and 6. This load should be of sufficient value to allow the unit to operate at its maximum rated current and voltage output.
4. Apply nominal AC input power to the unit and check for normal operation. Satisfactory operation at this time would indicate that any malfunction previously encountered, is external in nature. All interconnections and loads normally used in conjunction with this power supply should then be carefully checked for electrical defects.

4.3 TROUBLESHOOTING

1. Set VOLTAGE ADJUST and VOLTAGE VERNIER controls fully CW. Using a 20,000 ohms per volt voltmeter or oscilloscope, check the voltages across the various circuit components listed in the TROUBLESHOOTING GUIDE, located immediately before the schematic diagram at the rear of this instruction manual. The sample voltages listed in this guide apply only if the unit is operating at its nominal AC input, and has a dummy load of sufficient size connected across its output to allow operation at maximum rated current and voltage output levels. Any reading which is grossly incorrect indicates that the stage being tested or the one immediately preceding it, is defective. The Block Diagram, Schematic Diagram and appropriate sections of the Theory of Operation will prove helpful in any troubleshooting work. Proper polarity to be observed when testing can be easily obtained from the Schematic Diagram.

2. If voltage checks show no noticeable deviations from the prescribed values, disconnect AC power and proceed with point-to-point resistance checks across pots, switches, diodes, resistors, transistors, in that order.

3. When the trouble is of an intermittent nature such as poor regulation, ripple, etc., the use of an oscilloscope to determine dynamic changes will be necessary.

SECTION 5

CALIBRATION

5.1 GENERAL

The following adjustments should be made when necessary to assure optimum operating characteristics and maximum efficiency of the Trygon power supply.

5.2 TEST EQUIPMENT REQUIRED (or equivalent)

(A) Oscilloscope, Tektronix Type 561
(B) Differential Amplifier Plug In, Tektronix Type 63
(C) Time Base Plug In, Tektronix Type 67
(D) Systron Donner Multimeter Model 9025
(E) Variable Auto transformer, Powerstat Type 3PN136 (20 Ampere rating)

Shorting Link Application

For test purposes, shorting links should be connected across terminals 1 and 2, 2 and 3, 5 and 6, 6 and 7, to provide local sensing and local voltage programming. To reduce pick up, shielded wire must be used for all conncetions between test equipment and the power supply being tested. To prevent ground loops, it is important that only one ground connection be made, as shown in Figure 5-1 and Figure 5-2. Tighten all terminal connections as securely as possible, and set all front panel controls fully CW.

5.3 CALIBRATION PROCEDURE

Pre- Regulator

A) With power supply operating without a resistive load across the output terminals, vary VOLTAGE ADJUST control until 100% of rated voltage output is indicated on the DC voltmeter. Set AC POWER switch S1 to OFF, and connect resistive load across the output terminals. Set AC POWER switch S1 back to ON, and adjust resistive load for rated current setting on ammeter.

B) Set oscilloscope to DC triggering mode and connect scope input across the positive terminals of input capacitor C16 and output capacitor C9.

C) Adjust Pre-Regulator Input Balance control R53 for a balanced 120 cps sawtooth shaped waveform.

D) Adjust Series Pass Voltage control R49 for approximately 10 VDC, measured between the positive terminals of input capacitor C16 and output capacitor C9.

E) Vary AC input power 10% above and below the nominal input level. Observe that the voltage measured between the positive terminals of the input and output capacitors, does not vary by more than 1.5 VDC, at either input voltage extreme.

Voltage Adjust Control

A) Maximum Voltage

Set front panel VOLTAGE ADJUST and VOLTAGE VERNIER controls fully CW. Adjust Maximum Voltage control R86 to obtain an output voltage 0.5 VDC in excess of the maximum rated output voltage.

B) Minimum Voltage

Set front panel VOLTAGE ADJUST and VOLTAGE VERNIER controls fully CCW. Adjust Minimum Voltage control R87 to obtain a negative output voltage of 0.1 VDC.

C) Readjustment

Adjustment of either Maximum Voltage control R86 or Minimum Voltage control R87 will have an effect upon the other. Therefore, these controls should be readjusted if necessary, as outlined in above paragraphs (A) and (B), upon initial completion of this adjustment.

NOTE

If partial rotation of the VOLTAGE ADJUST controls produces no apparent change in indicated output voltage, furthe rotation of these controls should not be attempted. Rotation of these controls fully CCW with little or no output voltage regulation can result in damage to the controls, the load, or both. Set the AC POWER switch to OFF, and proceed with the troubleshooting outlined in Section 4 (MAINTENANCE) of this instruction manual.

Set front panel VOLTAGE ADJUST and VOLTAGE VERNIER controls fully CCW and observe that the voltage indicated on the unit and test voltmeters drops slightly below the zero setting of the meters. The output voltage should be slightly negative. Reset voltage controls fully CW.

Current Adjust Controls

A) Maximum Current

Connect a test ammeter having a full scale current indicating capacity of 150% that of the rated current output across the output terminals of the power supply. (Set all front panel controls fully CCW.) Apply power to the unit under test and slowly rotate CURRENT controls fully CW. Observe that the maximum current obtainable is approximately 105% that of the maximum rated current output. If it is not possible to achieve 105% of the maximum rated current output, adjust Maximum Current control R37 until that value is attained. Set AC Power Switch to OFF. Connect a suitable load resistance across the output terminal connections. The load resistance must be able to dissipate the rated power of the unit (P = IE) and must be of sufficient value to yield the rated output current when the rated voltage is applied. Set AC Power Switch to ON. Note the voltage indicated on the DVM. Disconnect the resistive load from the output and observe the voltage indicated on the DVM. The maximum change in output voltage should not exceed by more than 0.01% or 3mv (whichever is greater) that of the output voltage indicated with the load resistance applied across the output terminals.

If it is not possible to maintain the load regulation as stated in the preceding paragraph, readjust Maximum Current control R37 slightly and recheck the load regulation.

B) Minimum Current

Connect test ammeter, having a full scale current indicating capacity of 100 ma, across output terminals in place of a load resistor. Set all front panel controls fully CCW and apply power to the unit under test. Slowly rotate VOLTAGE ADJUST control in a CW direction, until current meter indicates a current flow somewhere between 0-50ma. Adjust Minimum Current control R29 for a nominal current indication of 1% of the rated current. Set POWER ON switch S1 to OFF.

Constant Voltage Operation

A) Load Regulation

With the equipment connected as shown in Figure 5-1, connect a suitable load resistance across the Output terminal connections. The load resistance selected must be able to dissipate the rated power of the unit (P = IE) and must be of sufficient value to yield the rated output current when the rated voltage is applied. Note the voltage indicated on the DVM. Disconnect the resistive load from the output. The maximum change in output DC voltage indicated on the DVM should not exceed by more than 0.01% or 3mv (whichever is greater) that of the output voltage indicated with the load resistance applied across the output terminals.

B) Line Regulation

Place the resistive load across the output and note the voltage indicated on the DVM. Vary the AC input power 10% above and below the nominal AC input level. The maximum change in output voltage should not exceed by more than 0.01% or 2mv (whichever is greater) that of the output voltage measured at either extreme of the AC input.

C) Ripple Voltage

In order to reduce pickup, shielded test leads should be used in making ripple measurements. With the resistive load connected across the output terminals, measure the AC ripple with the AC DVM. Vary the AC input power 10% above and below the nominal AC input level. The maximum ripple amplitude should not exceed 0.5 mv RMS.

Constant Current Operation

A) Load Regulation

With the equipment turned off, disconnect the resistive load from the utput terminals. Connect a small current sensing resistor in series with the resistive load and then connect the load back across the output terminals. Selection of the proper value for the current sensing resistor may be easily made using the formula $R_S = I/I_R$ where R_S = Value of Current Sensing Resistor and I_R = Rated Load Current. Connect the equipment as shown in Figure 5-2, and apply power to the power supply.

Vary the VOLTAGE ADJUST controls and resistive output load as necessary, to achieve rated current and voltage output. Decrease the load resistance until current meter reading exceeds full scale indication. Rotate CURRENT ADJUST control CCW to return the current meter reading to full scale. Observe that the output voltage has decreased from its previous full scale reading, and that increasing the VOLTAGE ADJSUT contols has no effect upon the output voltage or current. This indicates that the unit is now operating in the Constant Current Mode.

Measure the voltage across the small sensing resistor. Compute and note the current flow through this resistor. Change the output load from the resistive load previously used, to a short. Again measure the voltage across the small sensing resistor and compute the value of the current flow through this resistor. The change in current should not exceed by more than 0.5% the rated current previously noted with a full resistive load across the output.

B) Line Regulation

Replace the resistive load across the output and measure the voltage drop across the small sensing resistor. Compute and note the current flow ($I = \frac{E}{R}$) through this resistor.

Vary the input line voltage between 105 and 125 VAC. Note the maximum change in voltage across the sensing resistor and compute the maximum current flow. The maximum change in current should not exceed by more than 0.5% the rated current previously noted at either extreme of the AC input.

C) Ripple Current

With the AC input line voltage adjusted to the nominal value of 115 volts and the resistive load connected across the output, measure the amplitude of the AC ripple as seen across the sensing resistor with the AC VTVM. Compute and note the current flow. Vary the AC input line voltage between 105 and 125 VAC. Measure the maximum voltage drop and compute the maximum current flow. The maximum ripple current must not exceed by more than 0.25% or 5 ma (whichever is greater) that of the current flow noted during nominal input line voltage.

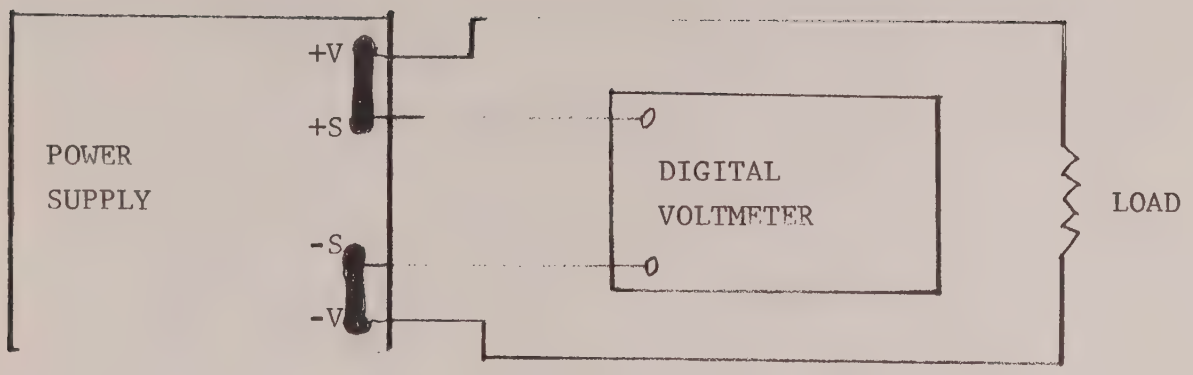


FIGURE 5 - 1

CONSTANT VOLTAGE OPERATION

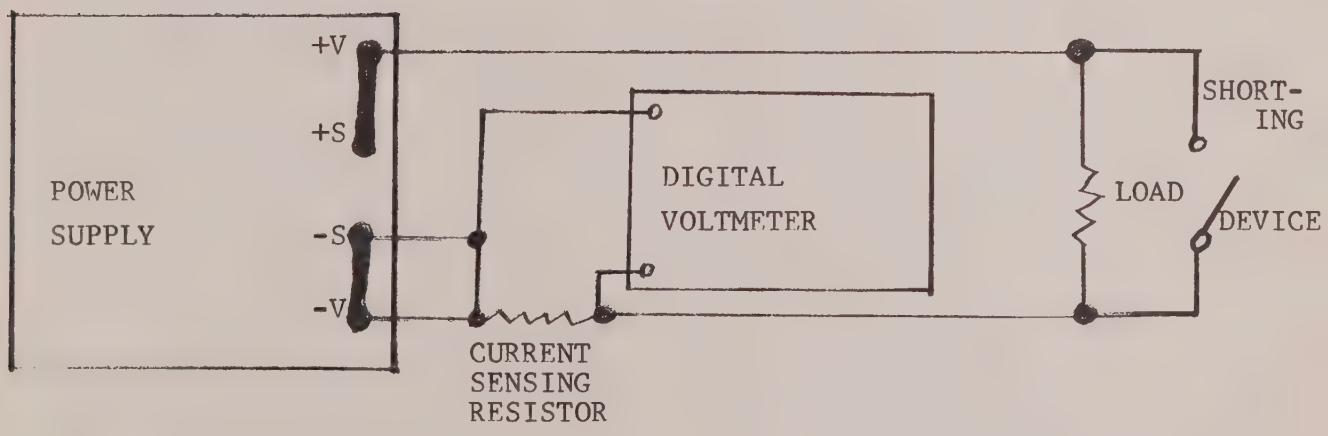


FIGURE 5 - 2

CONSTANT CURRENT OPERATION

E L E C T R I C A L P A R T S L I S T -- HR20-12C

REFERENCE	COMPONENT	MFR	MFR PART NUMBER	STOCK #
C 1	CAP 500MF-75V	00835	DRWG	820010
C 2	CAP .15MF 250V		MKT1813	800210
C 3	CAP .1MF 250V	24138	CM	800185
C 5	CAP .047 250V		MKT1813	800147
C 6	CAP .0033MF 600V	33498	GP332K	800025
C 7	CAP .01MF-600V	33498	ACOM GP103P	800090
C 9	CAP 12000MF-40V	00835	DRWG	820334
C 11	CAP .22MF 250V		CM	800252
C 16	CAP 37500MF .35V	00835	DRWG	820393
C 19	CAP .01MF 600V	33498	ACOM GP103P	800090
C 20	CAP .1MF 250V	24138	CM	800185
C 21	CAP .001MF 600V	33498	GP102M	800006
C 22	CAP 10MF 50V	90210	TTX106N050AOLIP	810010
C 23	CAP 6.8MF 35V		CS13BF685K	821021
C 25	CAP .01MF 600V	33498	ACOM GP103P	800090
C 29	CAP 68MF-6V		T360B686M006AS	821019
C 30	CAP 68MF-6V		T360B686M006AS	821019
C 33	CAP 0.1MF-250V	24138	CM	800185
C 35	CAP 300MF-40V	56289	39D307G040FJ4	810184
C 47	CAP .01MF-600V	33498	ACOM GP103P	800090
C 4	CAP 68MF 50V	00853	TYPE 556	810080
C 17	CAP 18MF 150V	09023	NLW18-150	810030
CR 1	DIODE 1N4004	21845	1N4004	710384
CR 2	DIODE 1N4004	21845	1N4004	710384
CR 3	DIODE 1N4004	21845	1N4004	710384
CR 4	DIODE 1N4004	21845	1N4004	710384

ELECTRICAL PARTS LIST -- HR20-120

REFERENCE	COMPONENT	MFR	MFR PART NUMBER	STOCK #
CR 4	DIODE 1N4004	21845	1N4004	710384
CR 5	DIODE 1N4004	21845	1N4004	710384
CR 6	DIODE 1N4004	21845	1N4004	710384
CR 7	SCR 93-3 MCR 649AP-3	04713	MCR649AP3	720290
CR 8	SCR 93-3 MCR 649AP-3	04713	MCR649AP3	720290
CR 9	DIODE 1N4004	21845	1N4004	710384
CR 10	DIODE ZENER 1N755A	81483	1N755A	720196
CR 11	DIODE ZENER 1N751A	81483	1N751A	720181
CR 12	DIODE ZENER 1N1360A	81483	1N1360A	720241
CR 13	DIODE ZENER 1N751A	81483	1N751A	720181
CR 14	DIODE 1N2163A	24444	IN2163A	720262
CR 15	DIODE 1N4004	21845	1N4004	710384
CR 16	DIODE 1N4004	21845	1N4004	710384
CR 17	DIODE 1N4004	21845	1N4004	710384
CR 18	DIODE 1N4004	21845	1N4004	710384
CR 22	DIODE ZENER 1N751A	81483	1N751A	720181
CR 26	DIODE 1N4004	21845	1N4004	710384
CR 27	DIODE 1N4004	21845	1N4004	710384
CR 28	DIODE 1N4004	21845	1N4004	710384
CR 29	DIODE 1N4004	21845	1N4004	710384
CR 31	DIODE 1N4004	21845	1N4004	710384
CR 33	DIODE E016-G20	05828	G20	720060
CR 34	DIODE 1N4004	21845	1N4004	710384
CR704	DIODE 1N4004	21845	1N4004	710384
CR800	DIODE 1N4004	21845	1N4004	710384
DS 1	PILOT LIGHT	91802	104032	770020

ELECTRICAL PARTS LIST -- HR20-12C

REFERENCE		COMPONENT	MFR	MFR PART NUMBER	STOCK #
DS	2	LIGHT IND 41N	91802	2190A87	770023
F	1	FUSE 10A-MDA-250V	75915	MDA	870201
L	1	CHOKE ASSY	09206		503017
L	2	CHOKE ASSY	09206		503017
M	1	METER 20VOLT HOYT	74542	#649-18	753393
M	2	METER 15A-EXT-HOYT	74542	#649	753374
Q	1	TRANS 16A507 2N2714	03508	2N2714	700180
Q	2	TRANSISTOR 2N2905A	04713	2N2905	705067
Q	3	TRANS 16A507 2N2714	03508	2N2714	700180
Q	4	TRANS 16A507 2N2714	03508	2N2714	700180
Q	5	TRANS 16A507 2N2714	03508	2N2714	700180
Q	6	TRANSISTOR 2N2905A	04713	2N2905	705067
Q	7	TRANS 16A507 2N2714	03508	2N2714	700180
Q	8	TRANS 16A507 2N2714	03508	2N2714	700180
Q	8	TRANS 16A507 2N2714	03508	2N2714	700180
Q	9	TRANS 16A507 2N2714	03508	2N2714	700180
Q	9	TRANS 16A507 2N2714	03508	2N2714	700180
Q	10	TRANS 16A507 2N2714	03508	2N2714	700180
Q	10	TRANS 16A507 2N2714	03508	2N2714	700180
Q	11	UNIJUNCTION UJ25	03508	UJ25	720145
Q	12	TRANS 16A507 2N2714	03508	2N2714	700180
Q	12	TRANS 16A507 2N2714	03508	2N2714	700180
Q	13	TRANS 2N3440	30045	DRWG	700205
Q	14	TRANS 2N4915	30045	DRWG	700191
Q	16	TRANS 2N3447	21845	SPEC CONT DWG	705071
Q	17	TRANS 2N3447	21845	SPEC CONT DWG	705071

REFERENCE		COMPONENT	MFR	MFR PART NUMBER	STOCK #
Q	18	TRANSISTOR 2N2905A	04713	2N2905	705067
Q	20	TRANS 2N3447	21845	SPEC CONT DWG	705071
Q	21	TRANS 16A507 2N2714	03508	2N2714	700180
Q	21	TRANS 16A507 2N2714	03508	2N2714	700180
R	1	XFORMER REV A	09206		500134
R	1	RWW 200-5W-5%		VALS	640389
R	2	RMF 9.95K-.5W-1%	12126	M1/2TI	620600
R	3	RCOMP 47K .5W	01121	RCR20	610340
R	4	RMF 1.18K-.5W-1%	12126	M1/2TI	620320
R	5	RMF 150-.5W-1%	12126	M1/2TI	620050
R	6	RMF 1.96K-.5W-1%	12126	M1 1/2 T1	620402
R	7	RMF 1.96K-.5W-1%	12126	M1 1/2 T1	620402
R	8	RCOMP 100 .5W	01121	RG20	610070
R	9	RMF 750-.5W-1%	12126	M1/2TI	620250
R	10	RCOMP 470 .5W	01121	RCR20	610140
R	11	RMF 1.96K-.5W-1%	12126	M1 1/2 T1	620402
R	12	RCOMP 220 .5W	01121	RC20	610100
R	13	RCOMP 560 .5W 10%	01121	RCR20	610150
R	14	RCOMP 100K-.5W-10%	01121	RCR20	610350
R	15	RMF 402-.5W-1%	12126	M1/2TI	620140
R	16	RMF 750-.5W-1%	12126	M1/2TI	620250
R	17	RMF 1.5K-.5W-1%	12126	M5T1	620360
R	18	RMF 1.96K-.5W-1%	12126	M1 1/2 T1	620402
R	19	RMF 1.96K-.5W-1%	12126	M1 1/2 T1	620402
R	20	RCOMP 100 .5W	01121	RG20	610070
R	21	RMF 750-.5W-1%	12126	M1/2TI	620250

REFERENCE	COMPONENT	MFR	MFR PART NUMBER	STOCK #
R 22	RMF 511-.5W-1%	12126	M1/2TI	620180
R 23	RMF 200-.5W-1%	12126	M1/2TI	620070
R 24	RLTC 50-3W-3%	83125	1300S	630220
R 25	POT 2K 100 2W	12697	DRWG 098060-5	605020
R 26	POT 2K 100 2W	12697	DRWG 098060-5	605020
R 28	RCOMP 4.7K-.5W-10%	01121	RC20	610250
R 29	POT 500 1.5W 110	11236	DRWG 099030-5	600146
R 31	POT 250 25 2W DUAL	12697	DRWG 098060-2	605010
R 32	RMF 301-.5W-1%	12126	M1/2TI	620110
R 33	RWW 0.1 25W		FR25	650040
R 34	RMF 604-.5W-1%	12126	M1/2TI	620210
R 35	RMF 1.96K-.5W-1%	12126	M1 1/2 T1	620402
R 36	RMF 1.96K-.5W-1%	12126	M1 1/2 T1	620402
R 37	POT 500 1.5W 110	11236	DRWG 099030-5	600146
R 38	RMF 301-.5W-1%	12126	M1/2TI	620110
R 39	RMF 124-.5W-1%	12126	M1/2TI	620040
R 41	RCOMP 470 .5W	01121	RCR20	610140
R 42	RCOMP 2.2K-.5W-10%	01121	RC20	610210
R 43	RCOMP 470 .5W	01121	RCR20	610140
R 45	RCOMP 82 .5W	01121	RCR20	610050
R 46	RMF 22.1K-.5W-1%	12126	M1/2TI	620675
R 47	RMF 18.2K-.5W-1%	12126	M1/2TI	620637
R 47	RMF 100K-.5W-1%	12126	M5T1	620800
R 48	RCOMP 6.8K-.5W-10%	01121	RCR20	610270
R 49	POT 25K .25W	11236	UPF2CORE	600364
R 52	RLTC 500-1W-3%	83125	1300S	630338

REFERENCE	COMPONENT	MFR	MFR PART NUMBER	STOCK #
R 53	POT 5K-1.5W-110	11236	DRWG 099030-10	600290
R 54	RCOMP 4.7MEG-.5W-10%	01121	RCR20	611135
R 55	RCOMP 10 .5W	01121	RCR20	610000
R 56	RCOMP 10 .5W	01121	RCR20	610000
R 57	RCOMP 220K-.5W-10%	01121	RCR20	610500
R 58	RCOMP 10K-.5W-10%	01121	RC20	610290
R 59	RCOMP 10K-.5W-10%	01121	RC20	610290
R 60	RMF 100K-.5W-1%	12126	M5T1	620800
R 61	RMF 22.1K-.5W-1%	12126	M1/2TI	620675
R 64	RWW.1-3W-10%	12697	CC30	640010
R 65	RWW.1-3W-10%	12697	CC30	640010
R 72	RWWS 1.5K 10W		VALIO	640527
R 73	RCOMP 100 .5W	01121	RG20	610070
R 75	RWW 350 5W 5%		VAL5	640431
R 76	RCOMP 1K-.5W-10%	01121	RC20	610180
R 77	RCOMP 1K-.5W-10%	01121	PC20	610180
R 78	RCOMP 150K-.5W-10%	01121	RCR20	610360
R 79	RCOMP 15K-.5W-10%	01121	RCR20	610300
R 80	RCOMP 4.7K-.5W-10%	01121	RC20	610250
R 81	POT ~~150~~ 50-1.5W-110	11236	DRWG 099030-3	600021 ~~600071~~
R 82	SHUNT 15 AMP	09206		048551
R 84	POT 250 25 2W DUAL	12697	DRWG 098060-2	605010
R 85	RWW.1-3W-10%	12697	CC30	640010
R 86	POT 150-1.5W-110	11236	DRWG 099030-3	600071
R 87	POT 150-1.5W-110	11236	DRWG 099030-3	600071

ELECTRICAL PARTS LIST -- HR20-12C

REFERENCE	COMPONENT	MFR	MFR PART NUMBER	STOCK #
R 88	RWW 10-2W 10%		VAL10	640190
R 98	RCOMP 100-.5W-10%	01121	RG20	610070
R 99	RCOMP 100-.5W-10%	01121	RG20	610070
R 108	RLTC 2.0-3W-3%	07088	KM300	630060
R 109	RCOMP 330-.5W-10%	01121	RC20	610120
S 1	SWITCH DPST	73559	2GK50-73XG182	880030

* ANY GOOD COMMERCIAL GRADE ELECTRICAL EQUIVALENT WHICH IS READILY AVAILABLE MAY BE USED.

E L E C T R I C A L P A R T S L I S T -- HR20-120V

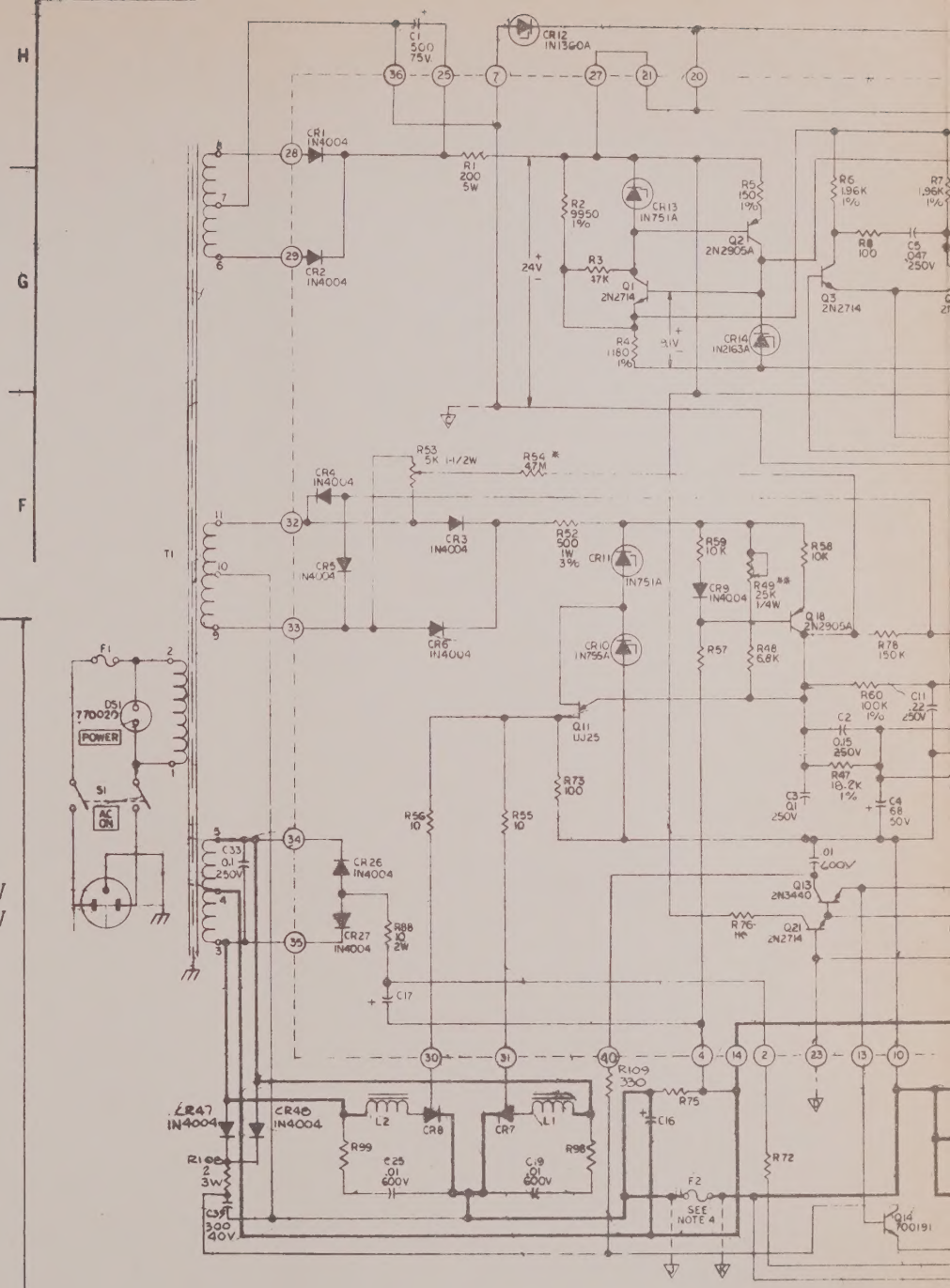
REFERENCE	COMPONENT	MFR	MFR PART NUMBER	STOCK #
C 32	CAP 0.1MF-250V	24138	CM	800185
CR 41	DIODE 1N4004	21845	1N4004	710384
CR 42	DIODE 1N4004	21845	1N4004	710384
CR 43	DIODE 1N4004	21845	1N4004	710384
CR 44	DIODE 1N751A	81483	1N751A	720181
CR 45	DIODE 1N1199A-1N3615	22888	DRWG	720129
CR 46	SCR MCR649AP-2	04713	MCR49AP2	720280
F 2	FUSE 20A-32V-FB	75915	FB	870110
Q 30	TRANS 2N2905A	04713	2N2905	705067
Q 31	TRANS 2N2905A	04713	2N2905	705067
Q 32	TRANS 2N2714-16A507	03508	2N2714	700180
R 100	RMF 1.96K-.5W-1%	12126	M1 1/2 T1	620402
R 101	RLTC 700-3W-3%	83125	1300S	630370
R 102	RCOMP 1K-.5W-10%	01121	RC20	610180
R 103	RCOMP 4.7K-.5W-10%	01121	RC20	610250
R 105	RCOMP 1K-.5W-10%	01121	RC20	610180
R 106	POT 5K-1.5W-110	11236	DRWG 099030-10	600290
R 107	RCOMP 15K-.5W-10%	01121	RCR20	610300

* ANY GOOD COMMERCIAL GRADE ELECTRICAL EQUIVALENT WHICH IS READILY AVAILABLE MAY BE USED.

E L E C T R I C A L P A R T S L I S T -- HR20-120VX

REFERENCE	COMPONENT	MFR	MFR PART NUMBER	STOCK #
CR 14	DIODE 1N2167	04713	1N2167	720139
Q 9	TRANS TR1000	94144	2N2223	700071
R 16	RLTC 750-3W-3%	83125	1300S	630375
R 17	RLTC 1.5K-3W-3%	83125	1300S	630420
R 21	RLTC 750-3W-3%	83125	1300S	630375
R 22	RLTC 550-3W-3%	83125	1300S	630350
R 23	RLTC 200-3W-3%	15915	TS3W	630270

* ANY GOOD COMMERCIAL GRADE ELECTRICAL EQUIVALENT WHICH IS READILY AVAILABLE MAY BE USED.



NOTES:

1. UNLESS OTHERWISE SPECIFIED:-
   ALL RESISTORS ARE IN OHMS, 1/2W
   ALL CAPACITORS ARE IN MICROFARA
2. * DENOTES SELECT IN TEST
3. △LETTERS IN TRIANGLES DENOTE O
4. WHEN O.V. CIRCUIT IS SPECIFIED, INS
5. LAST REF DESIGNATIONS USED:

ON COMPONENT BD	POWER & CIRCU
C35, Q21, CR48, R109	C25, F2, Q20, CR49, L2, R99,

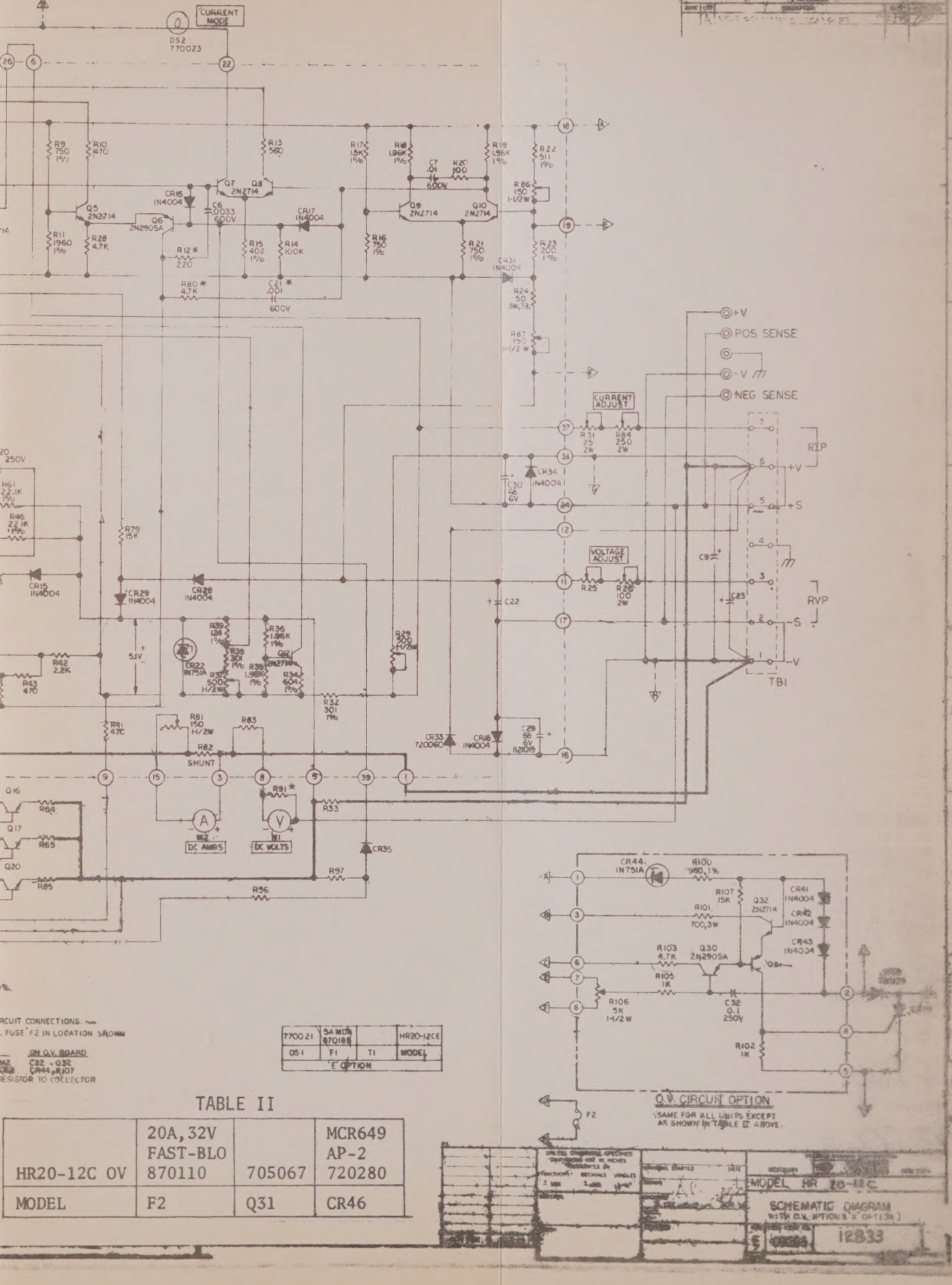
6. ** .3V ADJUSTED FOR 2.15V EMITT
   AT 105 VAC LINE & 20V AT 12 ADC OU

MODEL HR20-12C

T1	500134A
M1(V)	0-20
M2(A)	0-15
R47	18.2K,1%
C17	µF,150V
Q16,Q17	705071
Q20	705071
CR7,CR8	MCR649AP-3
CR35	OMIT
C9	10,000 µF,25V
C16	37,500 µF,35V
C22	10 µF,50V
R25	2K,2W
R33	0.1 Ω,25W
R57	220K
R64,R65	0.1 Ω,3W
R72	1.5K,10W
R75	350 Ω,5W
R82 SHUNT	15A
R83	19.95K,1/2%
R85	0.1 Ω,3W
R96	OMIT
R97	OMIT
L1,L2	503017
C23	6.8 µF,35V
R98,R99	100 Ω
F1 SLO-BLO	10A

FOR "X" UNITS (ULTRA HIGH STABILITY)

RLTC 750 3W,3%	RLTC 1500 3W,3%	RLTC 550 3W,3%	RLTC 200 3W,3%	1N2167 720139	700071 (DUAL)	NOT USED	HR20-12CX
R16, R21	R17	R22	R23	CR14	Q9	Q10	MODEL



770021	SAMICA 870188		HR20-12CE
DS1	F1	T1	MODEL
'E' OPTION			

TABLE II

	20A, 32V FAST-BLO		MCR649 AP-2
HR20-12C OV	870110	705067	720280
MODEL	F2	Q31	CR46